CHAPTER-II
REVIEW OF LITERATURE

The growth of an individual can be influenced by any of the different factors of genetic, environment, nutrition and sex dimorphism between the boys and girls especially during adolescence. Here are the reviews of the related literatures studied on the above factors in some other populations:

Growth Related with Genetic and Environmental Factors

Optimal growth depends on genetic constitution and environmental factors. Normal growth and development are finely regulated by a complex interaction of hormonal influences, tissue responsiveness and nutrition. Metabolic and genetic signals modulate these responses (Chrzastek-Spruch, 1984). Genes influence growth through the control of the production of enzymes needed for all the chemical reactions that are necessary for building up and maturation of various cells and systems, (Rona, 1981). Chatterjee et. al., (1999) reported that anthropometric measurements are more influenced by genetic factors than by environmental factors. They stated that all measurements are highly heritable components and that heritability estimates ranged from 40-91%. Nutrition, socio-economic conditions, exercise training and other environmental factors act independently or in concern to modify an individual's genetic growth potentials (Martorelli, 1977; Chrzastek-Spruch, 1984).

Genetic or non-genetic growth failure is a common outcome of diverse situations in which the need for energy and nutrients exceeds supply. Unfavourable diet, lack of care or infection can each deflect growth from its genetically determined course, which is restored by catch-up growth under appropriate conditions (Martorelli, 1977; Merchant, 1980). However, prolonged or repeated malnutrition, does depress final stature. Growth patterns as reflected by height, weight and other anthropometric measurements reflect population health. The development of norms and standards is of utmost importance in the evaluation of health and disease (Frisancho, 1990). The availability of population norms for growth and development is required to assess deviation from the normal for the particular population, as well as to monitor factors

affecting health and nutritional status of the population and to evaluate the effects of nutritional intervention (Cross et. al., 1995; Monir et. al., 2004).

Powloski et. al., (2004), described a cross-sectional growth study which reveals that the Nicaraguan girls are undernourished when compared with other Latin American girls living in an improved environment. The data also revealed that the Nicaraguan girls have better indicators of nutritional status when compared with a cohort of poor Gautemalan girls. Silventoinen (2008), reported that Growth is a complex process, and only little is known on the genetic regulation of it. Analyzing the effect of genetic and environmental factors on growth in a longitudinal Swedish cohort of 231 monozygotic and 144 dizygotic twin pairs born between 1973-1979 with length or height measured annually from birth to age 18 resulted that, at birth and 1 year of age, a substantial part of the variation in length was because of common environment (50 and 57%, respectively) and the effect of genetic factors was minor. After 2 years of age, 91-97% of the variation of height could be explained by genetic differences whereas the rest was because of environmental variation not shared by twins. The genetic correlation between heights at ages 2 and 18 was 0.73 (95% confidence intervals 0.68-0.77) showing that 53% of the genes affecting height at these ages are the same or closely linked; with increasing age the correlation with genetic effects at age 18 become subsequently stronger. Especially in mid-childhood, growth was largely regulated by the same genetic factors. During puberty new genetic factors started to affect height, but also genetic variation affecting height at previous ages remained. These results suggested that genetic regulation of growth is rather uniform, which is encouraging for further efforts to identify genes affecting growth.

Sauza (2006), analysed a cross-sectional measurements of Agta children and adults and of the mortality schedules in this population and aims to stress the influence of environmental pressures in the ongoing evolution of short statures. Recumbent length, height, weight, mid upper-arm circumference and triceps skinfolds were taken using standard methods from a total of 253 Agta individual. Exact or nearly exact ages were taken from a long-term demographic database. Agta individuals are both short and thin when compared to other populations. 34% of the adult were under-nourished, while 17% of the children were wasted, according to international standards. A major and

delayed peak of mortality in early infancy overlaps with a period of average decrease in body length in relation to the reference. Demographic indicators of poor health-related quality of life are consistent with slowed patterns of growth observed, stressing the importance of environmental pressure in maintaining the short stature of the Agta population.

Czerwinski (2007), estimated the influence of genetic factors on growth in stature during childhood and determines whether there are pleiotropic effects of genes influencing both childhood growth and later adult health outcomes using familial data. Serial stature data (i.e., birth to adulthood) from participants in the Fels Longitudinal Study were used to derive stature growth parameters. Adult health outcome data for each participant were available for at least one visit after age 30 years. Maximum likelihood-based variance component methods were used to determine the heritability of each parameter and to examine the relationships between growth parameters and adult health outcomes by estimating genetic correlations between the traits. Heritability estimates for the growth parameters are generally high and statistically significant ranging in magnitude from 0.65-0.98. Heritability for adult health outcomes are also significant ranging from 0.31-0.98. The phenotypic correlation analysis shows that stature growth parameters are significantly related to several adult health outcomes including stature, weight, BMI, systolic and diastolic blood pressure, percent body fat, fat-free mass, skeletal muscle mass in the arms and legs, and total body bone mass. The genetic correlation analysis reveals some evidence of common genetic pathways underlying certain aspects of growth and adult health outcomes including body composition and blood pressure variables.

Virani (2005), presented a longitudinal study on the secular trends in the dynamics of height growth over four decades. The study also aims to establish current norms for some biological parameters of growth and to address issues concerning ethnic variation and the effect of childhood physical activity on growth. 301 boys and 235 girls of Indian origin who had been enrolled in the Sri Aurobindo International Centre of Education (SAICE) by age 6 and remained for at least 3 uninterrupted years were divided into four birth cohort periods. Cross sectional and longitudinal analyses were carried out to derive distance, velocity and acceleration curves. No significant

differences were found between ethnic groups in any of the growth parameters. Over the 40 year span of this study, SAICE children prove to be taller than their Indian peers. A significant positive secular trend was seen in the height attained to all velocity turning points over the first two decades. Most pre-pubertal growth parameters in these children resemble those from developed nations. Children from most parts of India have similar genetic growth potential. After a significant positive secular trend in height attained over the first 20 years, the adult height has now plateaued. The significant difference in post-pubertal stature between the current generation and those of European origin indicates a genetic difference. Regular and graded physical activities have a salutary effect on growth. The data provide norms for healthy, active Indian child growing up in a satisfactory environment.

Pinotti (2002), has aimed in recording the conditions of life and of reproduction of the population of the rural districts of the Province of Chubut, in South Patagonia. These districts, where in 1991 more than 50% of the population lived in towns of less than 2000 inhabitants, have an important indigenous component of the Tehuelche and Mapuche ethnic groups, with particular behaviour affecting growth and development variables, patterns of food consumption, morbi-mortality, etc. in socio-economic and ecological context of considerable adversity. The climate is of low precipitation, less than 120 to 180 mm, producing an arid steppe environment. Seven anthropometric variables were measured on 678 children from 4 to 14 years of age to test for altered patterns of growth. Compared with another Argentinean population, it was found that there were differences in standing and sitting height, significant in some groups of age greater for national standards. Head circumference, weight, triceps and subscapular skinfolds showed the opposite relationship. Estimation was made that in this population there would be selected phenotypes adapted to adverse conditions.

Schell et. al., (2009), carried anthropometric measurements from the eligible participants between the age group of 10.0 to 16.9 and reveal that the people of Akwesasne have been affected by their exposure to toxicants that have entered the food chain after their release into the environment by local manufacturers. There is evidence of effects on prenatal and postnatal development. Levels of toxicants seen among the Akwesasne are sufficiently similar to levels in the general population of many countries

to suggest that toxicant effects may be widespread. The Akwesasne are one example of populations impacted by new environmental forces that impinge on development in prenatal and postnatal life with consequences for growth, development and later health as well. Viewing this study from within the historical context described at the beginning of this report, it is clear that environmental factors of new and familiar types continue to affect human growth and development. Further, many environmental features are socio-culturally mediated and their analysis involves sensitivity to the cultural milieu as well as the biological substrate.

Argnani et. al., (2008), stated that growth and development are clearly affected by high-altitude exposure to hypoxia, nutritional stress, cold or a combination of these factors. The present study evaluated the environmental impact on human growth by analyzing anthropometric characteristics of Tibetan children aged 8-14, born and raised above 4000 m altitude on the Himalayan massif in the prefecture of Shegar in Tibet Autonomous Region based on anthropometric traits and the nutritional status was assessed. Children permanently exposed to the high-altitude environment above 4000 m present a phenotypic form of adaptation and a moderate reduction in linear growth. However, it is also necessary to consider the effects of socioeconomic deprivation.

Piperata et. al., (2011), made a longitudinal study to assess the impact of economic change and increased market integration on subsistence strategies, living conditions, growth, and nutritional status of Ribeirinhos living in the rural Amazon, Brazil. Data on weight, height, skinfolds, and circumferences, as well as data on economic strategies and living conditions were collected from 469 individuals in 2002 and 429 in 2009. Of these, 204 individuals were measured on both occasions. Results indicate modest improvements in linear growth and among male children the observed increase was related to enrollment in the Brazilian conditional cash transfer program. Significant changes in weight and BMI were found among adult females and both were negatively related to household cash income. Despite significant changes in economic strategies and lifestyle, changes in nutritional status were modest which may be explained by increased food insecurity documented during this early stage of transition.

Gultekin et. al., (2006), studied to compare height and weight of school children of low socio-economic background with available growth data from high socio-

economic strata, and to verify the possible influences of three socio-demographic parameters on their growth. The sample consisted of 1052 girls and 1223 boys aged between 7-17 years, living in the outskirts of Ankara, a sub-urban area of poor socio-economic background. Children living in this area have lower mean values for height and weight when compared with growth data of upper socio-economic strata children. The differences were more pronounced during adolescence. Skinfolds were higher in girls than in boys at all ages. There was no clear relationship between growth and the number of siblings, the number of rooms in the house, the mother's and father's education, and the father's professional status, except of the height of girls. It is suggested that the lower growth status of children living in the outskirts of Ankara is attributable to the poor socio-economic status of this sub-urban population, which has not changed over the past decades. It is postulated that the growth impairment during adolescence might be due to a reduced tempo of growth in these children.

Freitas et. al., (2007), documented variation in somatic growth physical activity and fitness associated with socio-economic status (SES). The study involved 507 subjects (256 boys and 251 girls) from the Madeira growth study, a mixed longitudinal study of five cohorts (8, 10, 12, 14, and 16 years of age) followed at yearly intervals over 3 years (1996-1998). A significant difference between SES groups were observed from height, body mass and skinfolds. Boys and girls from high SES groups were fatter, heavier and fatter than their peers from average and low SES groups. At some age intervals, the high SES group had larger skeletal breadths (girls), girths (boys and girls) than low SES. Small SES differences were observed for physical activity. SES was significantly associated with physical fitness. At some age levels, boys from the low SES group performed better for muscular and aerobic endurance where as girls from the high SES group performed better for power.

Malhotra et. al., (2006), presented a study on an effort to explore the effect of high altitude on the physical growth of Spitian children. The cross-sectional study has been conducted on Spitian boys, ranging in age from 5 to 20 years. The adolescent spurt in case of Spitian boys occurs at 15-16 years of age in weight and 13-14 years in height whereas the peak adolescent gain in chest circumference is even later and takes place at 17-18 years. It can be concluded from the above results that the adolescent spurt is

delayed in spatian boys. The proportionally greater chest cage size has emerged as the most important morphological characteristic in various studies. This seems to be an adaptation to low pressure of oxygen. A very late adolescent spurt in chest circumference might be giving an edge to the high altitude population to keep on adding the final adult dimension by way of extending the growth period.

Bhasin et. al., (2008), presented a paper which deals with the growth patterns of Jammu and Kashmir State, India. The study includes population groups from all the three main divisions of the state. They are Dogra Brahman, Dogra Rajputs, Dogra Scheduled Caste and Gujjars from the Jammu region. From the Kashmir valley, Kashmir Muslim adults were studied whilst the population groups from Ladakh include Bodhs, Baltis and Tibetans Refugees. The subjects (N=2,043) were studied for a set of 23 anthropometric and 3 physiological variables. The results of the study show that various Dogra groups have better growth rates and higher values of physiological variables as compared to their peers. In general it has been observed that, the physical growth status of various population groups is proxy indicator of their economic prosperity and nutritional intakes.

Rao et. al., (2004), carried a cross-sectional study on 956 Yata boys and 899 Yata girls aged 0+ to 18+ years in rural school situated in Visakhapatnam district of Andhra Pradesh (South India) during July 2002 to June 2003. It has been observed that there is progressive increasing trend in all the dimensions with advancement in age. The study reveals that the adolescent growth spurt or highest peak velocity of girls (12+ and 13+ year) is attained earlier by two years than boys (14+ and 15+ year). Bhalla (2003), studied a distance and a velocity pattern of growth for body weight and height of 134 well-off Chandigarh boys aged 9-17 years, and 109 girls aged 9-16 years followed a mixed longitudinal growth study. Marginally, higher height growth attainments noticed in Chandigarh children in contrast to their other Indian counterparts during initial years of adolescence, shows that Chandigarh children are in process of expressing their genetic growth potential to its full which has not yet been fully achieved. The rate (velocity) of weight and height growth in Chandigarh children remained substantially lower than their sex-matched British counterparts throughout the period of study. The shorter height and lighter weight growth attainment noticed in Chandigarh children in

contrast to their Western counterparts may be attributed to slower and lesser magnitude peak growth velocities recorded in Chandigarh children.

Khongsdier and Mukherjee (2003), presented a study which base on a cross-sectional sample of 1.351 urban Khasi boys aged 3-18 years belonging to these three religion groups (Traditional religion, Christianity amd immigrant Muslim), with a view to understand the effects of socio-economic factors in growth and nutritional status, using anthropometric variables such as weight and height. There were significant differences between religious groups in respect of anthropometric variables. Allowing for household income, the ANCOVA test indicated that Muslim Khasi boys, who were the offspring of intermarriages between Khasi females and immigrant Muslim males, were significantly heavier and taller than Christian and Niam Khasi boys almost across the ages. It looks as though genetic mechanisms like heterosis and/or gene flow might also be associated with the larger body size in Muslim boys, such a conjecture could only be substantiated or refuted by further studies concerning genetic and more socio-economic data on both immigrant and non-immigrant populations.

Growth related with Nutrition

Oyhenart et. al., (2008), analysed the nutritional status of urban and rural school children from Mendoza (Argentina), but avoided rural and urban categorization by generating subpopulations as a function of their socio-environmental characteristics. Nutritional status differed across groups, whereas, overweight was similar among the groups and obesity higher in urban-middle income children. Urban differences were manifested mainly as underweight, but rural children exhibited the greatest stunting and wasting. Thus the negative effects of environment on nutritional status in children are not restricted to poor periurban and rural areas, though these are indeed unfavourable environment for growth, some urban families provide children with sufficient quantity and diversity of foods to expose them to obesity. By contrast, the more affluent urban families would appear to have greater possibilities for allowing their children to adopt a healthy life style. Although the causes of differences in nutritional status between middle and high-income urban groups are not clear, these determinants probably involve economic as well as educational influences.

Miyoshi et. al., (2005), carried a cross-sectional study to assess the nutritional status of children aged 3–15 years in remote villages of Lao People's Democratic Republic (PDR). Study sites were chosen from two provinces: Luang namtha (north) and Sekong province (south). All the samples are of 1075 children. This study confirmed the high prevalence of growth retardation among children, as well as persistent food insecurity in the remote areas of Lao PDR. Prevalence of stunting was 74.1 % in Luang namtha and 62.6 % in Sekong province, with school-aged children being worse-off than under-five ones. Children's diets were inadequate in quality as well as in quantity, with very limited availability of rice and other food items throughout the year. Also suggested the negative outcomes of government's development programme were often overlooked, and that more attention should be paid on the fragile living conditions in the resettlement villages, especially for the ethnic minority.

Nwokoro et. al., (2006), carried an anthropometric assessment of the nutritional status and growth of 2,012 randomly selected males and females between the ages of 10-20 years was carried out by cross-sectional method in Benin City Metropolis. Anthropometrical indices considered were weight, height and arm circumference. Percentile values (10^{th}, 50^{th} and 90^{th}) which represent the growth standards of males and females were established from this study. Comparisons were made by comparing the 50^{th} centile curves for height and weight of males and females obtained from this study with those of the WHO/NCHS standards. The results of the comparison revealed that the 50^{th} centile curves of subjects from Benin City consistently lagged behind those of WHO/NCHS standards for all the anthropometric variables considered, except the 50^{th} centile curve of females for height which showed that the 50^{th} centile curve of females from Benin City compared favourably with the WHO/NCHS standards, and do not fall below them. The age of puberty was determined from this study to be 15.5 years for females and 18 years for males.

According to Fredriks et. al., (2000), since 1858 an increase of mean stature has been observed in the Netherlands, reflecting the improving nutritional, hygienic, and health status of the population. In this study, stature, weight, and pubertal development of Dutch youth, derived from four consecutive nationwide cross-sectional growth studies during the past 42 years, are compared to assess the size and rate of the secular

growth change. Data on length, height, weight, head circumference, sexual maturation, and demographics of 14500 boys and girls of Dutch origin in the age range 0–20 years were collected in 1996 and 1997. A positive secular growth change has been present in the past 42 years for children, adolescents, and young adults of Dutch origin, although at a slower rate in the last 17 years. Height differences according to region, educational level of child and parents, and family size have remained. In girls, median age at menarche has decreased by 6 month during the past four decades to 13.15 years. Environmental conditions have been favourable for many decades in the Netherlands, and the positive secular change in height has not yet come to a halt, in contrast to Scandinavian countries. Main contributors to the increase in height may be improved nutrition, child health, and hygiene, and a reduction of family size.

Pawloski (2002), examined anthropometric and reproductive data on 1,056 adolescent girls (aged 10–17 years) from the Segou Region of Mali. When compared to the reference population, the Malian girls exhibited poorer indicators of growth and development. Z-Scores for height-for-age and weight-for-age were below 0 at all ages. Urban girls had better indicators of growth than rural girls. The body composition data show that the Malian girls have lower body fat than reference girls. Menarche was delayed by about 1.5 years compared to girls from the United States and Europe. Delayed growth and development may be due to many factors, including a history of undernutrition, poor socio-economic status, and increased energy demands.

Shahabuddin et. al., (2000), assessed the nutritional status of adolescent boys and girls in rural community in Bangladesh. Between December 1996 and January 1997; a cross-sectional survey was carried out in 803 households, each containing at least one adolescent, sampled consecutively from four purposely-selected villages in Rupganj Thana. Narayanganj district, initially, the guardians of 1483 healthy and unmarried 10-17 years old adolescents. Ogechi et. al., (2007), provided information on anthropometry, body composition and energy intake of adolescents of South Eastern Nigeria. The participants were 190 apparently healthy adolescent boys and girls aged 15-18 years with equal sex distribution. Participants were subjected to anthropometric measurements viz: height, weight, arm circumference and skinfold thickness. Energy intake was determined from individual weighed inventory for three consecutive days including a

week-end day; part of the food sample was subjected to chemical analysis. The result shows that there was undernutrition among the adolescents though the extent was higher among adolescent boys than girls, body composition of the adolescents was equally low. Also protein intake was grossly inadequate in both sexes. Therefore there is a need for improvement in the nutritional status among these adolescents.

Bener and Kamal (2005), conducted a cross-sectional study on the patterns of growth in height and weight and the prevalence of over-weight among Qatari school children aged 6-18 years. The growth patterns of the Qatari children, aged 6-18 years, appeared to be comparable with those of the NCHS/CDC reference. The weight-for-age centile curves of the Qatari boys tended to be superior to those of the NCHS/CDC reference until the age of 15 years, less so those of the Qatari girls. In contrast, the height-for-age centile curves of the Qatari children tended to deviate in a negative sense from the NCHS/CDC reference curves, for boys and girls from age around 11 years and 13 years respectively. The deviation of the smoothed median height-for-age curves from the reference in adolescence could most likely be attributed to a later maturation among the Qatari children. The prevalence of under-weight, over-weight, and obesity for the Qatari children was quite below the CDC and IOTF rates, except for girls aged 6-9 years. More males than females were over-weight or obese according to either the local, the CDC, or the IOTF reference, and the prevalence increased with age. A good percentage of the Qatari children were at risk of being over-weight, which needs more attention because the development of obesity results in different types of diseases associated with changes in body composition.

Zia-ud-Din and Paracha (2003), studied on two public and two private high schools representing boys from lower to middle-higher income families were selected for the assessment of their nutritional status. Two hundred boys aged between 11-15 years from each school were enrolled for the study. Weight, height, triceps skinfold and mid arm circumference measurements of the boys were taken and semi-quantitative food frequency and socioeconomic questionnaires were filled by interviewing the boys. The study concludes that the nutritional status of the boys studying in the private schools was better than those studying in the public schools and that family size and income were partly responsible for their better nutritional status.

Kanao et. al., (2009), conducted an investigation on anthropometric nutritional indicators that correlated with socio-demographic and economic factors among preparatory school-aged children (PSC) in the Gaza Strip. The study subjects were chosen purposively from three different socio-demographic and economic areas in the Gaza Strip: the Jabalia refugee camp (JRC), Gaza City (GC), and Al-Garrara village (GV). The overall prevalence of overweight among the female and male pupils was 17.0 and 17.1%, whereas obesity for both sexes was 5.45 and 7.42%, respectively. Moreover, there were highly significant statistical relationships between age and overweight or obesity. The highest percentages of overweight and obesity among the boys were recorded in GC. On the other hand, obesity was very significantly related to the mother's education level among the female pupils in JRC. Moreover, a highly significant relationship was observed between overweight and income among the boys in the same camp. There was also a highly significant relationship between obesity and the father's job among the boys in GV. The overall prevalence of thinness for the boys was higher than the girls. The difference in thinness values between the two sexes according to age was not statistically significant. The highest percentage (11.8%) of thinness was recorded among the girls in GC. There were no significant relationships between thinness and socioeconomic factors among PSC in the Gaza Strip ($p>0.05$). Thinness and socioeconomic relationships in the three different socioeconomic areas among PSC were not observed. The overall prevalence of stunting among the boys was higher than among the girls. The highest percentage (10.8%) of stunting among the boys was recorded in GV. It was also found that stunting was significantly related to the father's job among the boys in JRC. Similar to the thinness, significant relationships between stunting and socioeconomic factors among PSC in the Gaza Strip were not observed. These nutritional indicators showed a very significant difference between the male and female pupils according to region of residence. No statistical relations were observed between any of the indicators and the socioeconomic factors among the study samples in GC. About 10% of adolescent pupils in the Gaza Strip suffer from malnutrition that is significantly associated with the region. Moreover, relationships between malnutrition and socioeconomic variables among the PSC were heterogeneous and require further investigations.

Haboubi and Shaikh (2009), studied on the assessment of nutritional status of adolescents of Indian origin living in India and United Arab Emirates (UAE) to see how variable the prevalence is of stunting and wasting among adolescents of the same ethnic background living in different socio-economic and demographic environments. A study was conducted on 2459 boys and girls between ages of 10 and 16 years old. The rate of stunting and thinness was higher in the Indian adolescents from India when compared with adolescents living in UAE. The study was done in two groups having a common ethnicity but living in different socio-economic environments. With the results of this study, we can say that, improved economic conditions favour better expression of genetic potential for physical growth.

Ghosh et. al., (2009), carried out a study to determine the prevalence of under nutrition among the Nepalese children of Khatmandu valley, the capital of Nepal. The assessment of nutritional status of children is a very good indicator of socio-economic growth of community and the present study reveals that a high prevalence of undernutrition exists in Nepalese children, although the magnitude of undernutrition is similar in both boys and girls. Une and Soumay (2009), conducted a study to assess the nutritional status of school aged children (6-17 years) in Makurdi, capital of Benue state-Nigeria. It was found that males recorded a relative high rate of undernutrition than females. The study reveals that, the average of school children in Makurdi is undernourished. Poor nutrition of children does not affect the cognitive development of children but also likely to reduce the work capacity in future. Manocha (2004), says that nutritional status needs more care and attention in the childhood period, on comparing the nutritional status of the male children was found that children of this age group (15 to 16 years) had the problem of severe malnourishment, this shows that the period during childhood years need more care.

Malhotra and Passi (2007), assessed the diet quality and nutritional status of beneficiaries of Adolescent Girl scheme, a national programme targeted towards their nutrition/health needs. 209 girls (aged 11-21 years) from six rural blocks - Delhi (Alipur, Kanjhawala and Mehrauli), Haryana (Madhosinghana), Rajasthan (Deeg) and Uttar Pradesh (Fatehpur Sikri) comprised the sample. Weight and height were measured and dietary intake data were gathered by one day 24 hour recall coupled with food

frequency approach. Incidence of thinness (BMI for age <5th percentile) and stunting (height for age <3rd percentile) was 30.6% and 29.7%. The subjects followed a two meal pattern and their diets were monotonous and cereal-based. 49.3% of them were found to have energy intake less than 75% of RDA while a substantial proportion of them had inadequate nutrient intake with respect to most of the micronutrients especially iron (84.7%), folic acid (79.4%) and vitamin A (73.2%). The mean daily intake of milk and milk products, pulses, green leafy vegetables, other vegetables and fruits was grossly inadequate meeting only 47%, 36%, 26%, 34% and 3% of the suggested allowances; that of fats/oils and roots/tubers was somewhat adequate meeting 65% and 72% of the allowances while the intake of cereals and sugar was almost adequate revealing a deficit of only 7% and 3%. The study reveals not only a high incidence of under-nutrition but also an inadequate energy/micronutrient intake among the beneficiaries of Adolescent Girl scheme. Therefore, sustained efforts are needed to strengthen the scheme for improving its field-level implementation.

Mitra et. al., (2002), carry a cross sectional study of the physical growth status on 655 Kamar children (341 boys and 314 girls), aged 5 to 18 years, in the Raipur district of Chhattisgarh. The study aimed to find out the growth pattern of the Kamar children, which is considered to be a primitive tribe of Chhattisgarh, India and was compared with another Indian tribe and the official data for all India (ICMR). Anthropometric measurements included height, weight, sitting height, biacromial diameter, biilliocristal diameter, upper arm circumference, calf circumference and measurements of the triceps and subscapular skinfolds. All anthropometric measurements except skinfold thickenness exhibit uniform increase with age in both sexes. However, when height and weight of the Kamar boys and girls were compared with the data for other tribes and for all India, the Kamar children (both boys and girls) indicated lower weight and height and the difference showed to be significant, for almost all ages. Kamar boys showed higher anthropometric values than girls in almost all measurements except in biilliocristal diameter and in measured skinfolds. Poor socio-economic status of this primitive tribe may be one of the reasons for this poor growth pattern. However, in-depth study is necessary in order to arrive at any basic conclusions and to recommend any policy and interventions.

Bharati et. al., (2005), assessed the nutritional status of school age children of Raichur region using the anthropometric measurements of 560 children. 50% belonged to rural area and other half to schools of urban area. The nutritional status of children from rural and urban areas was lower than the NCHS standard. Girls showing lower measurements than boys. The children from urban area were better than their rural counterparts in all the measurements though the percentage of wasted and stunted children was in rural areas.

Venkaiah et. al., (2002), studied the current diet and nutritional status of rural adolescents in India. National Nutrition Monitoring Bureau collected information in the rural areas of the nine States. In each State, 120 villages were selected from eight districts. From each of the selected villages, 20 households (HHs) were selected from five clusters. The information on socio-demographic profile was collected in all the 20 households, while anthropometric data such as weight, height and clinical signs of nutritional deficiency was collected on all the available adolescents in the selected households. In every fourth sampled household, i.e., five HHs, dietary information on all the members was collected using 24 hour dietary recall. The prevalence of undernutrition is higher (53.1%) in boys than in girls (39.5%). The extent of stunting was higher (42.7%) among adolescents belonging to the scheduled caste community. In the case of girls, the extent of underweight was considerably less in each age group than their male counterparts. About 70% of adolescents consumed more than 70 % of RDA for energy. The intakes of micronutrients such as vitamin A and riboflavin were woefully inadequate. The extent of undernutrition was high among adolescents and was higher among boys than girls. Adolescent girls in the rural areas could be at greater risk of nutritional stress because of early marriage and early conception before completion of their physical growth

Bose et. al., (2008), studied on a total of 454 (201 boys and 253 girls) Bengali Hindu children aged 6-14 years in a cross-sectional study. Height and weight were measured and the body mass index (BMI) was calculated. Three indicators of nutritional status namely underweight, stunting and thinness, were used based on the National Centre of Heath Statistics (NCHS) < - 2 Z score values. Mean Z-Scores for weight-for-age (WHZ), height- for-age (HAZ) and BMI-for-age (BMIZ) were less than those of

NCHS in both boys as well as girls. Public health problem of undernutrition was classified according to the World Health Organization (WHO). The overall age and sex combined prevalence of underweight, stunting and thinness were 16.9%, 17.2% and 23.1%, respectively. Both sexes had similar rates of stunting (boys = 14.4%; girls = 19.4%). However, there were significant ($p < 0.05$) sex differences in the frequency of underweight and thinness. Significantly more boys were underweight (boys = 20.9%, girls = 13.8%) and thin (boys = 27.8%, girls = 19.4%). Based on the WHO classification of severity of malnutrition among children, the overall age and sex combined rates of underweight, stunting and thinness were medium (10-19%), low (<20%) and very high (15%), respectively. While both boys (14.4%) and girls (19.4%) had low rates of stunting (<20%), the rates for thinness among both sexes (boys = 27.8%, girls = 19.4%) were very high. The rates of underweight were high (20-29%) and medium (10-19%), among boys (20.9%) and girls (13.8%), respectively.

Chakraborty (2008), carried out a cross sectional study on 123 Santal children of Ghatsila in Jharkhand and 105 Santal children of Bolpur in West Bengal (aged 6 to 10 years) to assess and compare the physical growth and nutritional status. Growth pattern of height, weight, BMI and mid-upper arm circumference was determined. It was observed that growth pattern of Santal boys and girls were similar between Ghatsila and Bolpur. Prevalence of undernutrition, though very high, was found to be similar between Santal boys and girls of two regions, and in between Santal children of Ghatsila and Bolpur. However, the percentage of severe stunting (grade III) was higher in Santal girls of Bolpur (38.09%) than that of Ghatsila (5.18%). In Santal boys, the severe undernutrition in terms of BMI was higher in Ghatsila (70.77%) compared to that of Bolpur (45.24%). The severe underweight and stunting were higher in Santal girls of Bolpur compared to the boys of same region. A poor growth rate and high prevalence of undernutrition were observed in the Santal children of two surveyed regions. Prevalence of undernutrition was higher in girls of Bolpur compared to boys.

Urade et. al., (2004), carried out a cross-sectional study with a view to assess the nutritional status among the growing children belonging to the Khaire Kunbi caste of Maharashtra. It is found that majority of the children suffers from various grades of malnutrition. The impact of malnutrition is more marked during early childhood period

and pubertal period resulting in high frequencies of wasting and stunting in both sexes. Sahani (2003), made an attempt to study the Jarawas, one of the hunting-gathering Negritos tribes of Andaman Islands on nutrition and health status. The findings show that Jarawas have lower BMI value than some of the other Negritos.

Mayuri and Madhavilatha (2000), had undertaken a study to find out the physical development of rural adolescents in Andhra Pradesh. The study sampled 1453 (boys=808, girls=645) adolescents from three regions of Andhra Pradesh. The results indicated that the rural adolescents consistently measured lesser than both ICMR, well-to-do as well as NCHS standards for their respective ages. However they were found to be in satisfactory nutritional status according to Body Mass Index. Correlation results pointed out that age, class and overall SES scores were significantly related to both weight and stature of the adolescents. Maity and Mukhopadhyay (2010), examined the pattern of physical growth of children and adolescents as well as to assess their nutritional status, in terms of anthropometric measures, among a marginalized social group, mainly engaged in sea fishing as a vocation. Anthropometric (height and weight) data were collected from 468 individuals of both sexes. The study participants include 257 males and 211 females aged 5+ years to 18+ years inhabiting nine contiguous villages in Digha and its neighbourhood. The result of the study clearly demonstrated that the growth pattern of the children and adolescents of both sexes is relatively slow compared with another fishing community in Andhra Pradesh. The prevalence of malnutrition as gauged through weight for age and height for age is quite high in the study population irrespective of sex. It appears that this marginalized community needs appropriate support in the domains of health and nutrition programmes in an effective manner so that the health of the children and adolescents can be better managed.

Bhasin and Jain (2007. 3), carried out a cross-sectional study consisting 2221 samples of 1133 males and 1088 females belonging to adolescent (8+ to 18+) age groups among the tribal groups namely Minas, Bhils, Sahariyas, Damors and Kathodis of Rajasthan. While comparing the present tribal groups for the mean values of height and weights was found that they were lower than the national and international standards. The present study shows a high prevalence of stunting (low height for age) and underweight (low weight for age) among both males and females. Females show a

higher percentage prevalence of chronic malnutrition with respect to height and also underweight than the males. Most samples fall much below the normal standards of weight for age. Thus malnutrition is largely prevalent among the tribal groups of Rajasthan and the condition is further aggravated as it appears in combination with PEM

Bhasin and Jain (2007. 1), made an attempt to study the nutritional status of the scheduled tribes of Rajasthan on the basis of body mass index. Cross-sectional data on 2928 samples belonging to both adolescents (8+ to 18+) and adult age groups (19 & above) were collected following the international accepted standards. All the populations show an increase in the mean values of BMI in both males and females with advancing age. High prevalence of undernutrition was observed in both adolescent's boys and girls of the present study on the basis of BMI. The results of chronic energy deficiency grades also clearly indicated a high prevalence of thinness. Bhils show the lowest BMI than their counterparts in the other tribes. Mina males and females exhibit highest mean valued of BMI at higher age groups.

Das and Bisai (2009), conducted a study to ascertain the level of undernutrition among Telaga adolescents in Kharagpur town. A total of 930 (472 boys and 458 girls) children were measured. The mean BMI of children had shown a consistently increasing trend in both sexes from age of 13 years onwards. Moreover, there is a gender bias in favour of girls in higher mean BMI at all ages except 10 and 13 years. The overall prevalence of undernutrition was 28.60%. The rates were significantly higher among boys (37.59 %) compared with girls (19.43%). Nutritional status of the studied children is not impressive especially among early adolescent and boys.

Nutritional anthropometry serves as a useful indicator of past and present nutritional status. Among various anthropometric measurements weight, height, arm circumference and skinfold thickness are used to assess the nutritional status. Anthropometry is a widely accepted tool for assessing the nutritional status of children. Studies in this regard reveal that weight for age, height for age and body mass index are good indicators of current nutritional status than any other measurements or indices. BMI ratio is also found to be a reliable index for assessing malnutrition in growing children. Prevalence rates of undernutrition were found to vary by age, sex and socio-economic status. Environmental stress particularly nutritional deficiencies and

associated infections, reduces childhood growth rates and delays maturation. Inadequate or unbalanced diet during childhood also has long-term repercussions on both physical growth and intellectual performance in later life (Singh and Sengupta, 2007).

Bisai et. al., (2011) carried out a cross-sectional study of 1094 (boys = 665; girls = 429) rural school children aged 11-18 years of Midnapore Sadar North subdivision, Paschim Medinipur District, West Bengal, India, to evaluate their growth pattern and nutritional status. It has revealed that boys were significantly heavier than girls from age 16 onwards; they were also significantly taller from age 14 years. The mean WAZ (weight for age Z-score) for boys and girls were -1.488 and -1.417, respectively. The corresponding mean values for HAZ (height for age Z-score) were -1.317 and -1.486. The overall rates of underweight and stunting were 28.3% and 27.8%, respectively. The prevalence of underweight was significantly higher among boys (31.0%) than girls (24.2%). These rates for stunting were 27.4% and 28.4%, for the boys and girls. The rate of underweight and stunting was more in late adolescents (15-18 years) than early adolescents (11-14 years). In boys, the prevalence of stunting was significantly (1.5 times) more in late adolescents than early adolescents. According to the WHO classification for assessing severity of malnutrition, the rates of stunting were medium in both sexes. The rates of underweight were high and very high for girls and boys, respectively.

Raj et. al., (2009), studied on the population of 25228 children using stratified random sampling method from schools in a contiguous area in Ernakulam District, Kerala, India. Weight and height were measured at two time points, one in 2003-04 and another in 2005-06. The paired data of 12129 children aged 5-16 years were analysed for the study. The mean interval between the two surveys was 2.02 ± 0.32 years. The percentage of underweight, normal weight, overweight and obese children in the year 2003-04 were 38.4%, 56.6%, 3.7%, and 1.3% respectively. The corresponding figures in year 2005-06 were 29.9%, 63.6%, 4.8% and 1.7% respectively. Among the underweight children, 34.8% migrated to normal weight status and 0.1% migrated to overweight status. Conversion of underweight to normal weight predominated in urban area and girls. Among the normal weight children, 8.6% migrated to underweight, 4.1% migrated to overweight and 0.4% migrated to obesity. Conversion of normal weight to overweight

status predominated in urban area, private schools and boys. Conversion of normal weight to underweight predominated in rural area, government schools and boys. Among the overweight children, 26.7% migrated to normal weight status, 16.4% became obese and 56.9% retained their overweight status. Of the obese children, 6.2% improved to normal weight status, 25.3% improved to overweight status and 68.5% remained as obese in 2005-06. There was significant difference in trends between socio demographic subgroups regarding conversion of underweight status to normal weight as well as normal weight status to overweight.

Rao et al., (2006), assessed the diet and nutritional status of adolescent population from the different tribal areas of India. The available database collected by National Nutrition Monitoring Bureau (1998-99) was utilized for this purpose. Data on a total of 12,789 (10-17 yrs) was included for the analysis. Four percent of the adolescent girls were married and less than 1% were either pregnant (0.4%) or lactating (0.7%) at the time of the survey. The mean intake of all the foodstuffs, especially the income elastic foods such as pulses, milk and milk products, oils and fats, and sugar and jaggery were lower than the recommended levels of ICMR. The intake of all the foodstuffs except green leafy vegetables was lower than that of their rural counterparts. The intake of all the nutrients were below the recommended level, while that of micronutrients such as iron, vitamin A and riboflavin were grossly inadequate in all the age and sex groups. About 63% of adolescent boys and 42% of girls were undernourished ($<5^{th}$ BMI age percentiles of NHANES). A significant association between undernutrition and socio-economic parameters like type of family, size of land holding and occupation of head of household was observed.

Medhi et. al., (2006), conducted a study to assess the growth and nutritional status of school age children (6-14 years) of tea garden workers of Assam. Assessment of nutritional status using WHO recommended anthropometric indicators reveal a high prevalence of malnutrition among tea garden school age children and maturation was both chronic and recent in nature. Medhi et. al., 2007, conducted a study to evaluate growth and nutritional status using weight and height based indicators among tea garden adolescent boys and girls of Assam aged between 10-18 years. Total numbers of 605 adolescents (boys-291, girls-314) participated in the study. School enrollment rate was

only 59.2%. Prevalence of stunting was 47.4% and 51.9% among boys and girls respectively relative to NCHS reference, which reduced to almost 30% while Indian reference data was used. Prevalence of thinness was higher among boys (59.5%) than girls (41.3%) counterparts. Mean BMI among girls was higher at all ages than boys. Almost half of the adolescents were stunted and most of them were thin. Problem of overweight was seen in less than 0.5% of adolescents. Factors typical to underdeveloped society seems to contribute to the moderate to high prevalence of undernutrition among adolescents working in tea gardens.

Singh and Sengupta (2007), studied in a sample of 256 boys and 257 girls aged 6-10 years of Sonawal Kacharis of Dibrugarh, Assam. The results of the study indicated that the nutritional status of the Sonawal Kacharis children is better than the other population groups of North east India so far studied. BMI seems to be the better indicator of nutritional status than any other indices taken. The nutritional status of the Sonawal children improves along with the increase in age. Khongsdier and Mukherjee (2003), said that it is generally believed that improvement in environment quality is the main factor responsible for the better growth and nutritional status of children in developing countries. However, it is not clear whether this better growth performance is also associated with heterosis and/or gene flow that may take place as a result of the geographical movement of individuals, or migration. A cross-sectional sample of the Khasi girls of Shillong in Northeast India was considered in the present analysis on 1368 girls aged 3-18 years. The results indicate that hybrid girls were larger than non-hybrid girls across ages. Such a higher anthropometric status in hybrid girls was mainly due to their higher growth velocities before the adolescent period. The effect of heterosis after household income was highly significant at many ages from 6 to 18 years, although it was not clearly perceptible in the case of subischial length. Subject to further studies, the role of heterosis and/or gene flow in influencing growth and development of children can not be completely ruled out; especially after 5 years of age when the variation in growth patterns is likely to be associated not only with the environmental quality but also with genetic mechanisms.

Jibonkumar and singh (2006) studied on the nutritional status of 4 to 10 year-old Sekmai children. The Sekmais belong to a section of the Meiteis of Manipur. They are

included in the scheduled caste list of the state. The study is based on height and weight of 731 children (360 boys, 371 girls). It aims to throw light on different conventional methods of nutritional assessments based on height and weight and their varied results. The Sekmai children are shorter in height and lighter in body weight from the American (National Center for Health Statistics) and Indian children in all the age groups. According to Waterlow's classification of height for age, 43.37% of the Sekmai children are malnourished, whereas Gomez's classification of weight for age shows 68.67% as malnourished of different grades. But if we look at the classification of Vishveshwara Rao and the Indian Academy of Paediatrics classification (IAPC), the Sekmai children's nutritional status is not disappointing. Rao's classification of height for age reveals 88.37% as normal while that of IAPC shows 71.70% as normal. Waterlow's classification of weight for height also depicts 89.74% of the children as normal

Anthropological Survey of India (2010), reported on the Western Angami children that out of 673 school going and adolescent boys, 51 (7.58%) are undernourished, 610 (90.64%) are normal, 7 (1.04 %) are prone to overweight and only 5 (0.74%) are overweight. In case of girls, out of 608 school going and adolescent girls, 60 (9.87%) are underweight, 531 (87.34%) are normal, 14 (2.30%) are prone to overweight while only 3 (0.49%) are overweight. Thus it is clear that among the Angami children, over weight varies inversely with age. It may be opined that the Angami Naga children are by and large well nourished. In comparing the height and weight of Angami children with the ICMR (1990), revealed that both height and weight of Angami children is slightly lower than that of ICMR standards. The pattern of growth curves of Angami children shows more or less similar pattern with the ICMR data. As per BMI percentile classification of WHO, 90.2% and 88.84% of Angami boys and girls respectively are normal. In general, it can be said that the nutritional status of Angami children is more or less similar with that of the Sekmai of Manipur and the Sonowal Kachari of Assam. The study also showed that about 6% of pre-school Angami children are undernourished, 15% are wasted, and 13% are stunted, indicating that the health of pre-school Angami children is much better than that of Nagaland in general, the nutritional status of Angami Naga children is between the affluent Indian children and that of the children of Nagaland.

Agrahar-Murugkar (2005) studied the nutritional status of 222 Khasi girls within age groups 4 to 6 years, 7 to 9 years, and 10 to 12 years. Heights of girls ages 7 to 9 years and 10 to 12 years and weights of all girls were significantly ($P < 0.05$) lower than the reference values for height (126.4 and 142.7 cm) and weight (19, 26.9, and 31.5 kg), respectively. The lowest Z scores (−1.5 to −1.0) and percentiles (10^{th}) for body mass index were seen in 12 years old girls. Girls aged 10 to 12 years had the highest incidence of moderate malnutrition. Severe stunting was observed in all groups. Average energy consumption was significantly ($P< 0.05$) lower than the recommended dietary allowance in all the age groups. Consumption of protein by children ages 7 to 9 years and 10 to 12 years was also significantly lower than the recommended dietary allowance. Consumption of calcium, iron, and carotene in children 10 to 12 years old was significantly ($P < 0.05$) lower than the recommended dietary allowance.

Sex Dimorphism

Sexual dimorphism in humans is the subject of much controversy, especially when extended beyond physical differences to mental ability and psychological gender. Obvious differences between males and females include all the features related to reproductive role, notably the endocrine (hormonal) systems and their physiological and behavioural effects. Such undisputed sexual dimorphism include gonadal differentiation, internal genital differentiation, external genital differentiation, breast differentiation, muscle mass differentiation, height differentiation, and hair differentiation. Externally, the most sexually dimorphic portions of the body are the chest, the lower half of the face, and the area between the waist and the knees.

There are sex differences in the body size, shape, tissue and bone structure. The most striking of these is, males have greater height and wider shoulders and females have larger hips, and these differences arise at adolescence. Of particular interest to researchers involved in the study of malnutrition in human populations is the relationship of sexual dimorphism to environmental quality and nutritional status. The basis for this interest lies in the greater report sensitivity of males than females to chronic nutritional stress (Greulich, 1957; Tanner, 1962). Because of the differentiate response to environmental stress of males and females patterns of sexual dimorphism

seen in healthy and well-nourished populations have been altered. Tanner (1998), has also suggested that, the difference between the sexes in height during adulthood is mainly due to the longer period of growth in males. Before adolescence, males have a relatively much greater spurt than females in respect of shoulder width, where as in the case of hip the latter exceeds the former. However, the greater length of the male legs relative to the trunk is a consequence of the longer prepubescent period of male growth, because the legs are growing faster than the trunk at this time, other sex differences still earlier. The male forearm is longer, relative to the upper arm or the height, than the females. This difference is already established at birth, and increases gradually throughout the whole growing period.

Adolescence begins with acceleration in the rate of growth prior to the attainment of sexual maturity and then merges into a decelerative phase, terminating with the attainment of adult stature. This time span in which the acceleration, deceleration and termination of growth takes place encompasses a significant portion of second decade in life. This constant phenomenon of adolescent growth spurt occurs in all children and results in the apparent sex differences observed in body size, build and proportions. The spurt may exist anytime between 11 and 17 years, while among girls the spurt begins about a year or two earlier than in boys (Tanner, 1962). Value of growth gradient elucidates that maturation in girls are faster than boys over all age groups and in all measurements except triceps (Ratnawali and Roy, 1997).

According to Gasser et. al., (2000), while there is an agreement that sex differences in height are small up to the onset of the pubertal spurt in girls, there has been some debate about the question of which, and to what extent, various growth phases contribute to the average adult sex difference of about 13 cm. There has been no consistent agreement between authors as to what extent this difference is due to the late onset of the pubertal spurt (PS) for boys and to what extent it is due to their more intense PS. Investigation on this question for the variables in height, sitting and leg height, arm length, bihumeral and biiliac width, had revealed that biiliac width is a special case since both sexes have roughly the same adult height size, but girls still have a shorter growing period. The gain for boys, when compared to girls, shows a very different pattern across variables: for legs, the additional growth due to the later spurt is responsible for most of

the sex difference (64%). On the other hand, for bihumeral width and sitting height, the more intense PS contributes almost 50% to the adult sex difference. An analysis across variables indicates that increments from 1.5 to 6 years largely compensate for deviations in infant morphology from adult morphology.

Semproli and Gualdi-Russo (2007) carried out an anthropometric survey was on 1,383 school students aged 5–17 years in Suba district (a rural area of western Kenya) to evaluate patterns of growth and nutritional status of the Luo population by assessment of the prevalence and trends of malnutrition among children and adolescents. Body size and proportion were computed from height, weight, sitting height, arm circumference, and skinfolds. Very few age-groups show significant sex differences for height, body weight, and arm muscle area. However, there are several differences in skinfold thicknesses and arm circumference, always with higher mean values in girls. Analysis of the nutritional status (weight-for-age, height-for-age, and BMI-for-age) shows significant differences among the age-groups in both sexes. Boys present lower Z-scores than girls and there are higher percentages of malnourished subjects (stunted and underweight) among the males. The Luo data were compared with those of other African populations. Their body dimensions, nutritional status, and growth are similar to those of the other sub-Saharan samples. The Luo children are generally undernourished at the older ages: adolescents (11–16 years of age) show the most severe undernutrition and the highest percentages of undernourished subjects. In addition to the higher risk of undernutrition in teenagers, an emerging problem of over-nutrition is evident among the younger age-groups, with a higher prevalence in females. These findings are discussed in light of sexual dimorphism in sensitivity to adverse environmental conditions.

Wehkalampi et. al., (2008), said that secular trends towards earlier puberty, possibly caused by new environmental triggers, provides a basis for periodic evaluation of the influence and interaction of genetic and environmental effects on pubertal timing. In such studies, a practical marker that reflects timing of puberty in both genders needs to be used. It was investigated that genetic and environmental influences on pubertal timing by using change in the relative height between early and late adolescence (HD:SDS, height difference in standard deviations) as a new marker of pubertal timing. HD:SDS correlated well with age at peak height velocity in a population of men and

women with longitudinal growth data. In 2,309 twin girls and 1,828 twin boys, HD:SDS was calculated between height SDs at age 11.5 and 17.5, and 14.0 and 17.5 years, respectively. Quantitative genetic models for twin data were fitted to estimate the genetic contribution to HD:SDS. It was also investigated whether the same genetic factors influenced individual differences between HD:SDS and development of secondary sex characteristics prospectively collected by pubertal development scale (PDS). Genetic effects contributed to 86 and 82% of the variance in HD:SDS in girls and boys, respectively, when using the same model including additive genetic and specific environmental factors. In girls, 30% and in boys, 49% of the genetic factors affecting PDS and HD:SDS were the same. Future comparison of the results of periodic evaluations allows estimation of possible changes in the effects of environment on timing of puberty. In such studies, HD:SDS can be used as a practical marker of pubertal timing.

Mukhopadhya et. al., (2005), carried out a cross-sectional study of 559 Bengalese adolescents (314 boys and 245 girls) of North 24 Parganas, West Bengal, was undertaken to study their age and sex differences in nutritional status. A clear cut age variation in the change of the rate of undernutrition varies between boys and girls. In general this study provided that the Bengalese adolescents had moderate rates of undernutrition. These rates are in general lower than those reported in other developing countries including previous Indian studies. The adolescent's growth spurt is a constant phenomenon and occurs in all children, though it varies in intensity and duration from one child to another. The peak velocity of growth in height averages about 10 cm a year in boys and slightly less in girls. In boys the spurt takes place on the average between 13 and 15 ½ years and in girls some two years earlier. Many of the sex differences of body size and shape seen in adults are the results of differential growth patterns at adolescence. The greater relative width of shoulders in the male and hips in the females is largely due to specific stimulation of cartilage cells.

Busi et. al, (2003), carried out a cross-sectional study on 834 Jalaris boys and 852 Jalaris girls aged between 0+ to 18+ years in urban schools situated in Visakhapatnam district of Andhra Pradesh (South India) during August 2000 to July 2001. Analysis of the data reveals that all the measurements show significant differences

by sex according to age, Jalaris boys and girls are taller and heavier than ICMR (1984) national standards. Bose et. al., (2006), studied a cross-sectional study to determine the magnitude of undernutrition among 549 school children (boys=291 and girls=258) aged 5-9 years of rural areas of East Midnapore district of West Bengal in India. The collected data was analyzed using the recommended indices of height-for-age (stunting) and weight-for-age (underweight) based on the NCHS standard. Prevalence of stunting (overall=29.7%, boys=29.6%, girls=29.8%) and underweight (overall=53.4%, boys=54.6%, girls=51.9%) was alarming among the children studied. There was no significance sex difference in nutritional status. Moreover, the age variations in stunting and underweight demonstrated similar age-trends for both the sexes. Relative to undernutrition levels identified in other Third World countries, rural Bengalee children of the present study had very high rates. This study provides evidence that undernutrition is still a leading problem among rural Bengalee primary school children of West Bengal and this has not improved inspite of nutrition intervention programme which are currently in operation.

Khalil and Khan (2004), carried out an anthropometric study on physical growth and nutritional status of rural school going children of Jawan block of Aligarh district on 1240 children, 888 boys and 352 girls of age group 6-14 years. The mean height and weight increase monotonically along with age along with high degree of positive correlation between height and weight in both boys and girls (except for 14 years of age for girls). The overall increase in a mean height is more in boys than girls but increase in mean weight was more for girls than boys. The finding concluded that the boys are taller than girls, but girls are heavier than boys at pre-puberty and puberty (14 years of age).

Basu et. al., (2010), carried out a cross-sectional analysis on the nutritional status of an ethno-homogenous sample of contemporary Khasi tribal adolescent cohort of age 11+ to 17+ years in the state of Meghalaya, India .This was achieved through the use of the following derived anthropometric measurements - total upper arm area (TUA), upper arm muscle area (UMA), upper arm fat area (UFA), and arm fat index (AFI). A total of 670 adolescents (335 boys; 335 girls) participated in this study. In comparison with North American NHANES 1999-2002 standards, UMA, a measure of upper arm muscle mass, was lower at all age groups in Khasi girls. Conversely, in Khasi boys, AFI, a

marker of upper arm fat mass was lower at all age groups, thereby showing a gender dimorphic difference in upper limb muscle and fat proportions. The finding was made that in upper arm indirect anthropometry, contemporary Khasi adolescent children remain nutritionally deficient with gender dimorphic muscle and fat proportions.